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California Institute of  
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***Tropospheric Emission Spectrometer***  
**Aura Air Quality Working Group**  
**Meeting – Oct 27, 2008**

# **Update on TES Air Quality Applications and Science Studies**

**Greg Osterman for the  
TES Science Team  
Jet Propulsion Laboratory/California Institute of Technology**

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# **Overview of the use of TES data**

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- Assimilation into CTM's
  - GEOS-Chem (University of Toronto)
  - RAQMS (NOAA/NESDIS, NASA LaRC)
- Use as boundary/initial conditions in regional models
  - EPA Region-9, Arizona St, UC-Berkely
  - NOAA/NCEP (Youhua Tang)
- Evaluation of Regional Models – O<sub>3</sub>, CO in Free Troposphere
  - Texas Commission of Environmental Quality (CAMx)
  - NOAA/NCEP Air Quality Forecasting Group (CMAQ)
  - University of Alabama – Huntsville (CMAQ)
  - University of Houston (CMAQ)
  - UCLA, JPL (CMAQ)
  - EPA ORD (Ammonia, Nighttime ozone)
- Science Studies



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## ***Tropospheric Emission Spectrometer***

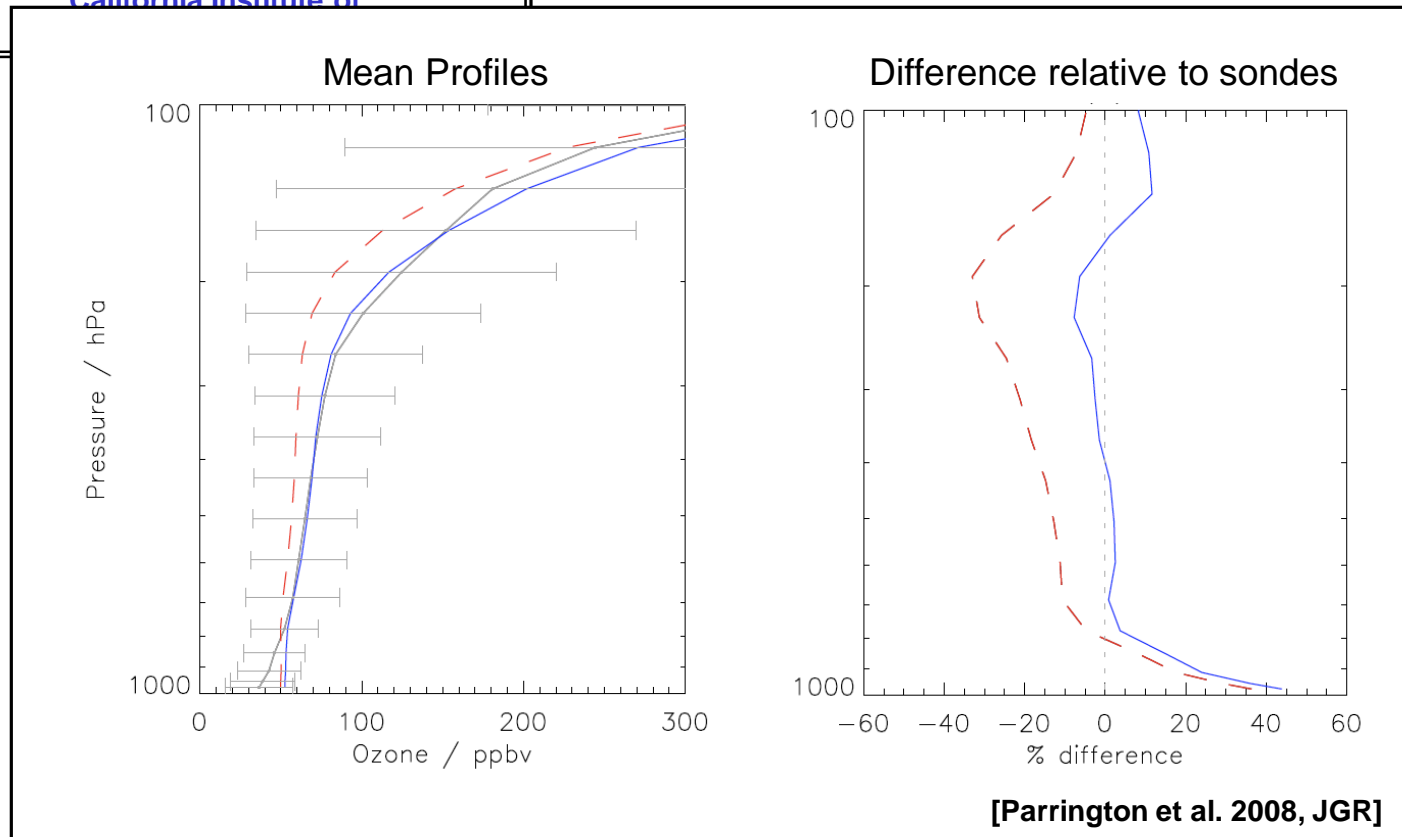
# **Assimilation of TES Data**

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## *Tropospheric Emission Spectrometer*

### Comparison to IONS-06 ozonesonde profiles, Aug 2006



➤ Figure shows mean (August 2006)  $O_3$  profiles, and differences, over North America (model sampled at the ozonesonde observation times and locations).

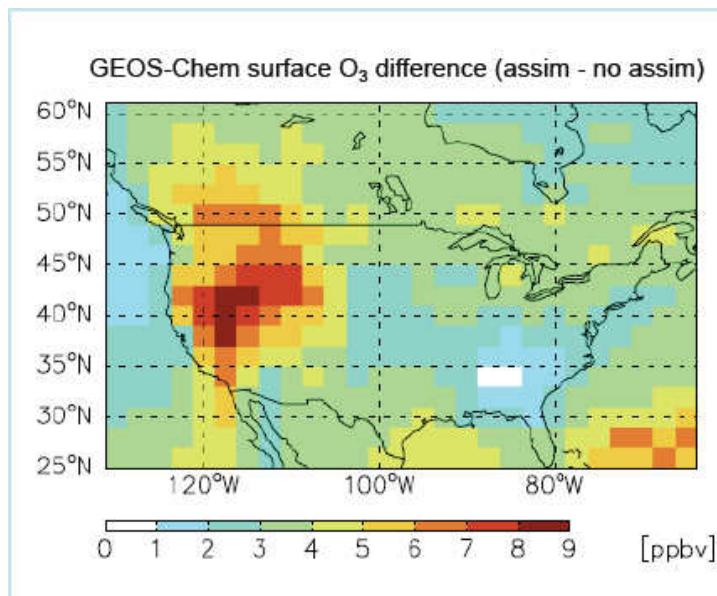
➤ Assimilation of TES  $O_3$  profiles in the GEOS-Chem CTM leads to significant improvements in the modeled free tropospheric (300-800 hPa)  $O_3$  distribution compared to ozonesonde profiles from the IONS-06 campaign in August 2006. The bias is reduced from a maximum of -35% to less than 5% (between 300-800 hPa).

**See M Parrington et al, – Wednesday PM**

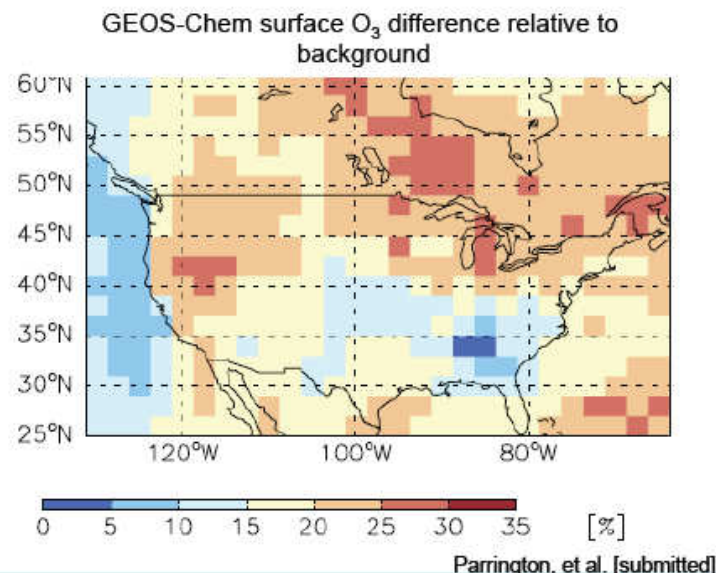


## Impact of TES O<sub>3</sub> assimilation on model surface O<sub>3</sub> across North America

GEOS-Chem surface O<sub>3</sub> difference (assim - no assim)



GEOS-Chem surface O<sub>3</sub> difference relative to  
background



- Assimilating TES data reduces the negative bias in the modelled free tropospheric ozone, enhancing the flux of background ozone into the boundary layer.
- The resulting increase in modeled surface ozone is greatest in western North America (as much as 9 ppbv) and smallest over the southeastern USA (less than 2 ppbv).
- The surface ozone increase in the assimilation implies an increase in background ozone of 20-30% in western USA and across Canada.



## Comparison to surface O<sub>3</sub> measurements, August 2006

| Location                  | Mean bias (std) | Mean bias (cda) |
|---------------------------|-----------------|-----------------|
| Kelowna, AB               | -1.81           | 4.52            |
| Bratt's Lake, SK          | 0.99            | 4.96            |
| Glacier NP, MT            | -5.61           | 0.65            |
| Pinnacles NM, CA          | -6.36           | 0.19            |
| Theodore Roosevelt NP, ND | -8.39           | -4.49           |
| Boulder, CO               | -3.90           | -0.37           |
| Table Mt., CA             | 0.64            | 6.47            |
| Dallas, TX                | 5.14            | 8.74            |
| Egbert, ON                | 1.63            | 4.90            |
| Narragansett, RI          | 8.21            | 11.26           |
| Coffeeville, MS           | 11.76           | 13.70           |
| Sumatra, FL               | 16.05           | 17.66           |

- Table of mean (August 2006) differences between surface O<sub>3</sub> measurements, from the EPA AQS and EC NAPS networks, and GEOS-Chem with (cda) and without (std) TES assimilation.
- Improvements in free troposphere, enhancing mass flux of O<sub>3</sub> across the boundary layer, improves modelled background surface O<sub>3</sub> (see highlighted locations).
- Despite the good agreement between the assimilation and ozonesonde measurements in the free troposphere, comparisons with surface measurements show that the assimilation exacerbates the bias in surface ozone, suggesting a potential model bias in the ozone sources and sinks or in the downward transport of ozone into the boundary layer.



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## ***Tropospheric Emission Spectrometer***

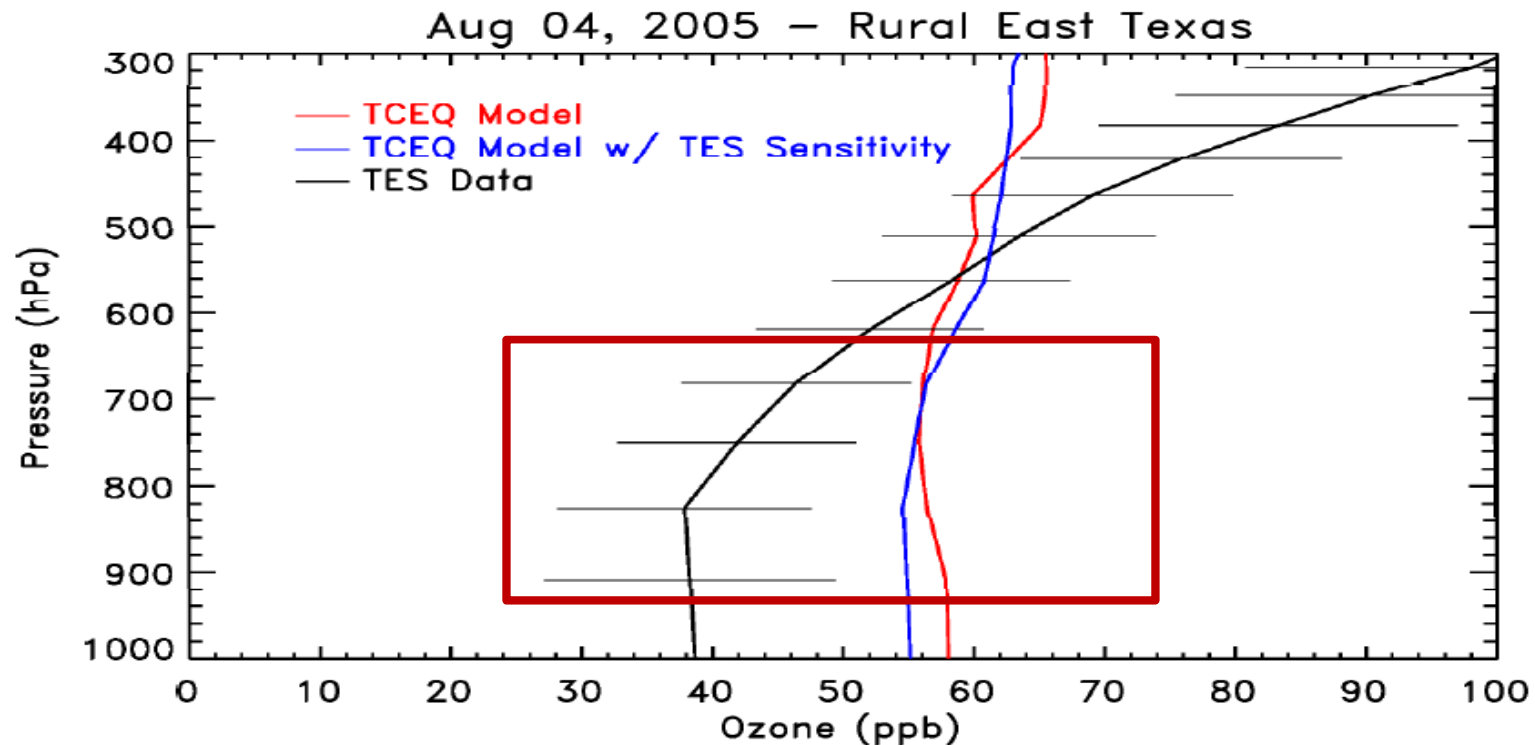
# **Evaluation of Regional Models**

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## *Tropospheric Emission Spectrometer*

### Model Ozone in Free Troposphere



- Beginning evaluation of initial CAMx model results with TES data
  - **Preliminary Result** – CAMx model higher than TES in lower troposphere
  - **Future Work:** Statistics of model/TES comparisons of O<sub>3</sub> and CO
- Future Work:
  - Comparison of MM5 temperature, humidity fields to AIRS and TES
  - Comparison of improved TCEQ treatment of sea surface temperature in MM5 with TES and AMSR-E





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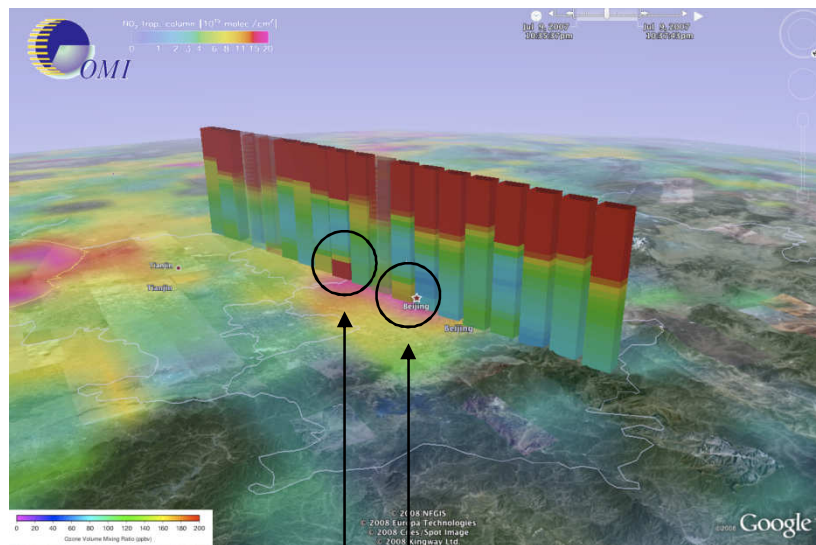
# ***Tropospheric Emission Spectrometer***

## **Science Studies**

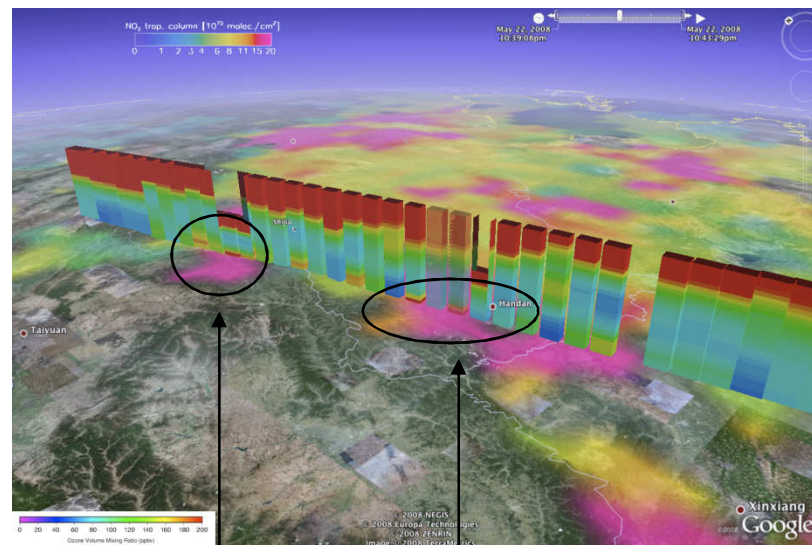
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# TES $O_3$ and OMI $NO_2$ near Beijing. Hamer, in prep

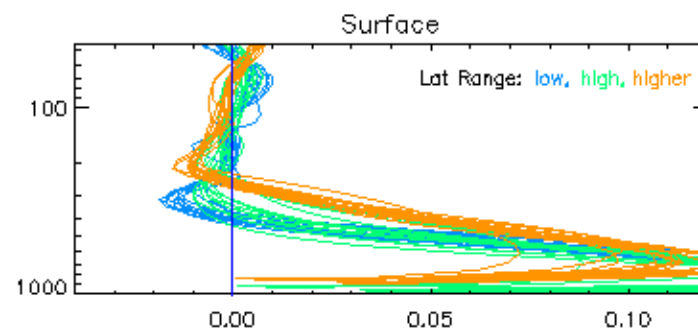
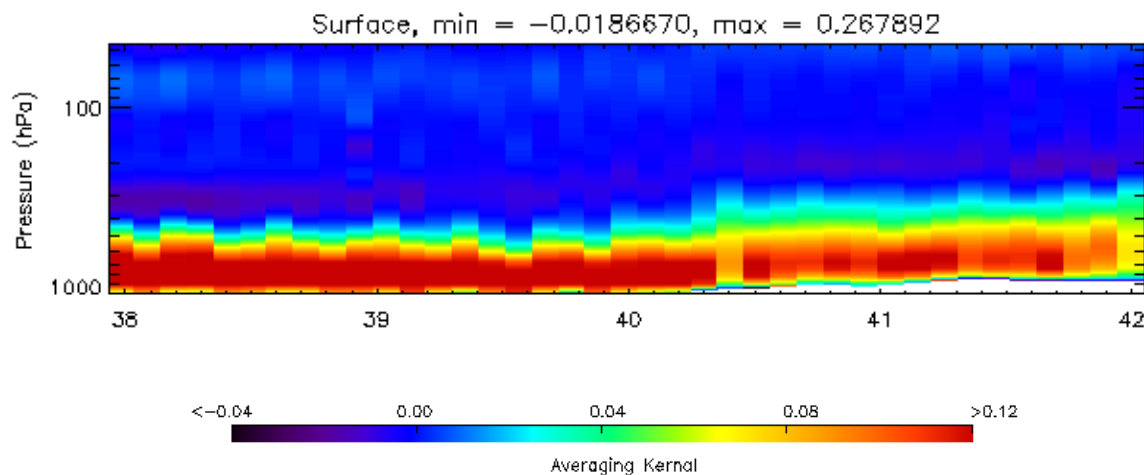
July 10th 2007



May 23rd 2008



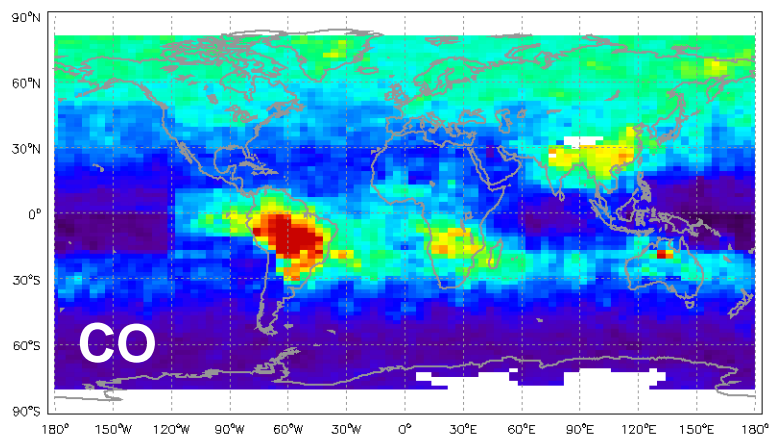
Elevated Ozone at 900 hPa seen co-located with elevated OMI  $NO_2$



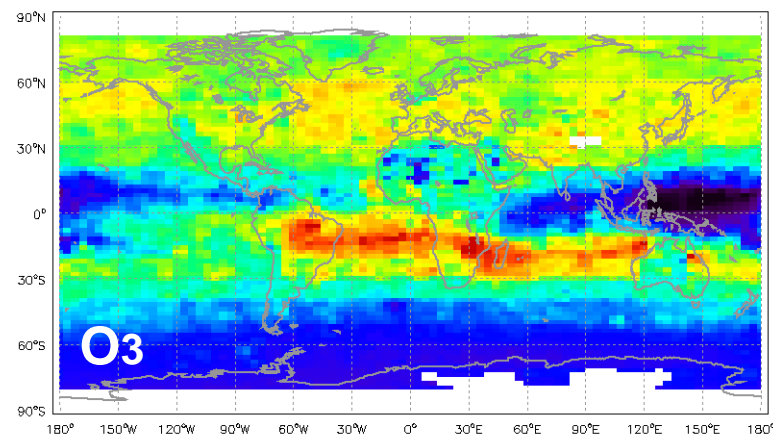


# ***TES Observations of Ozone and CO: Global Distributions in Lower/Mid/Upper Troposphere and their Time Trends in Selected Regions. Ming Luo. <http://tes.jpl.nasa.gov/visualization/>***

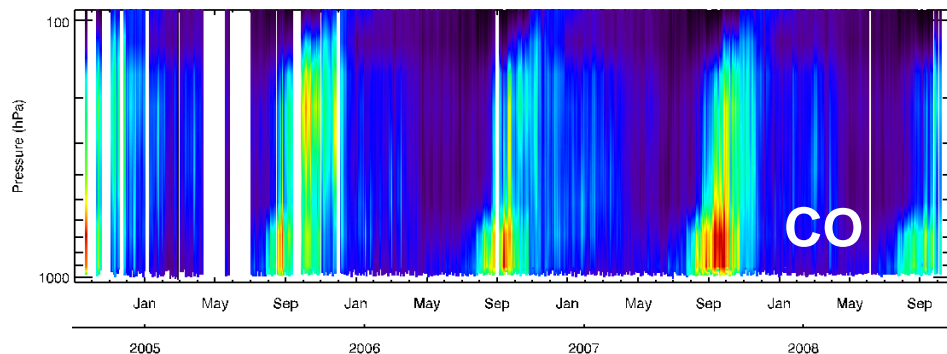
**Oct 2007, 681 hPa**



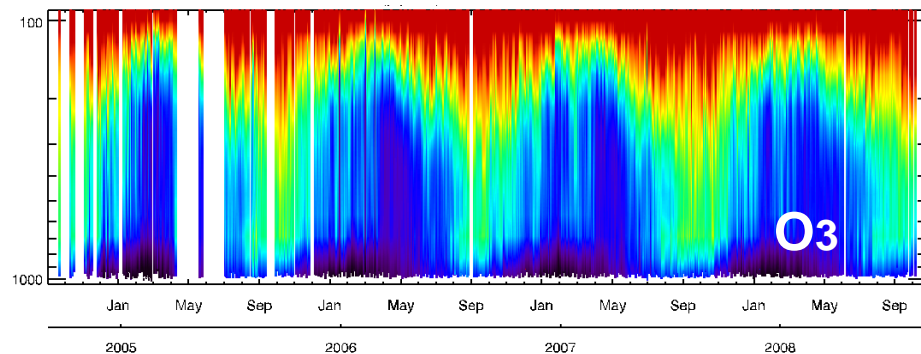
**Oct 2007, 681 hPa**



**Time Trend: South America**



**Time Trend: South America**



**See M Luo Talk – Thursday 10:45**



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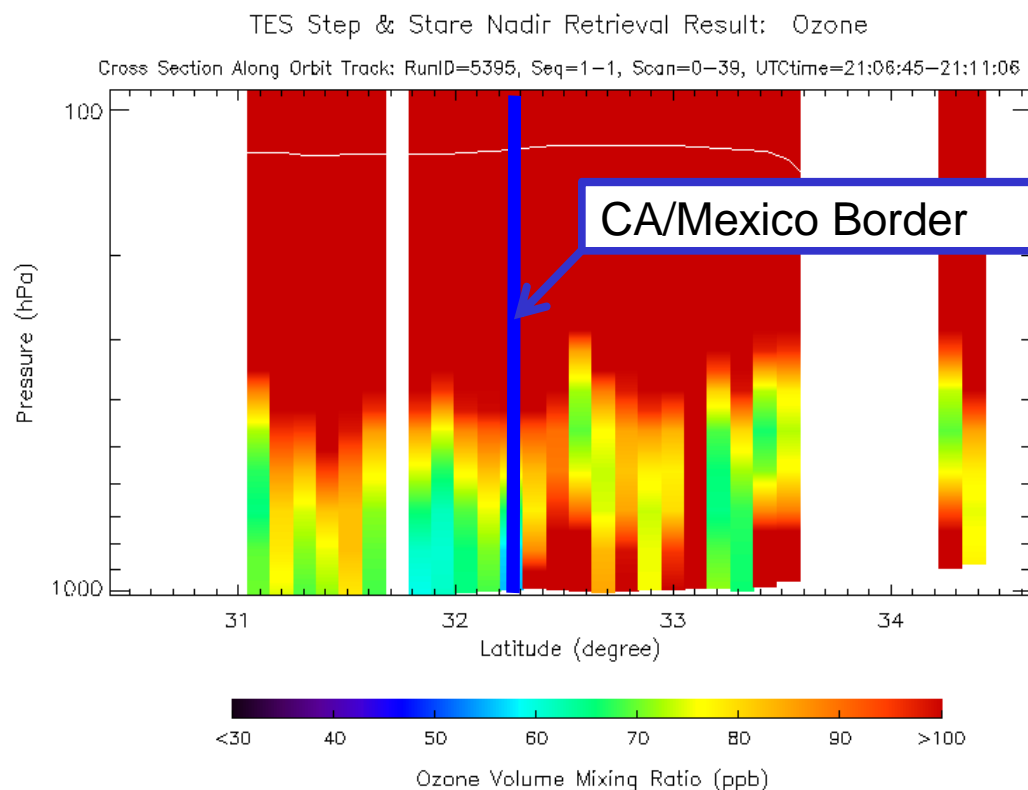
## *Tropospheric Emission Spectrometer*

Collaboration with EPA Region 9

**Aura Contribution:** Using OMI/MLS products to map tropospheric ozone along with the ability of TES to provide vertical information on ozone and carbon monoxide in the troposphere to help the EPA to understand air pollution events

**TES Contribution:** TES provided special observations across the US/Mexico border near San Diego and El Paso

**Future Work:** The work in this project is an example of how NASA satellite data might be used with EPA tools and health data for studying air pollution events and their health impacts



TES special observation near San Diego on June 7, 2007 showing enhanced levels of ozone in the lower troposphere on the US side of the border (San Diego)

EPA surface monitors measured low surface ozone in areas near TES measurements

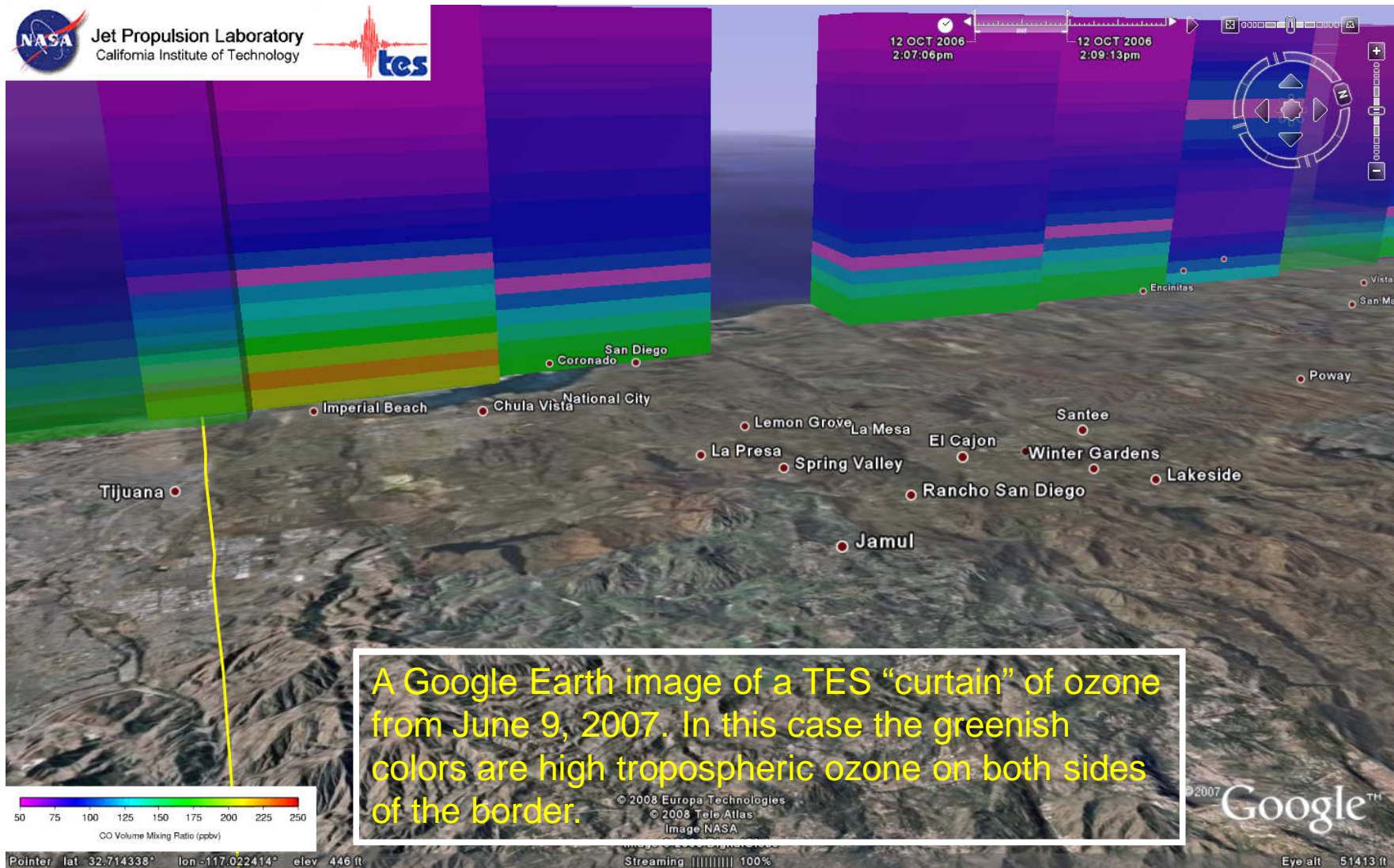




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## *Tropospheric Emission Spectrometer*

June 7, 2007 – TES Transect over US/Mexico Border

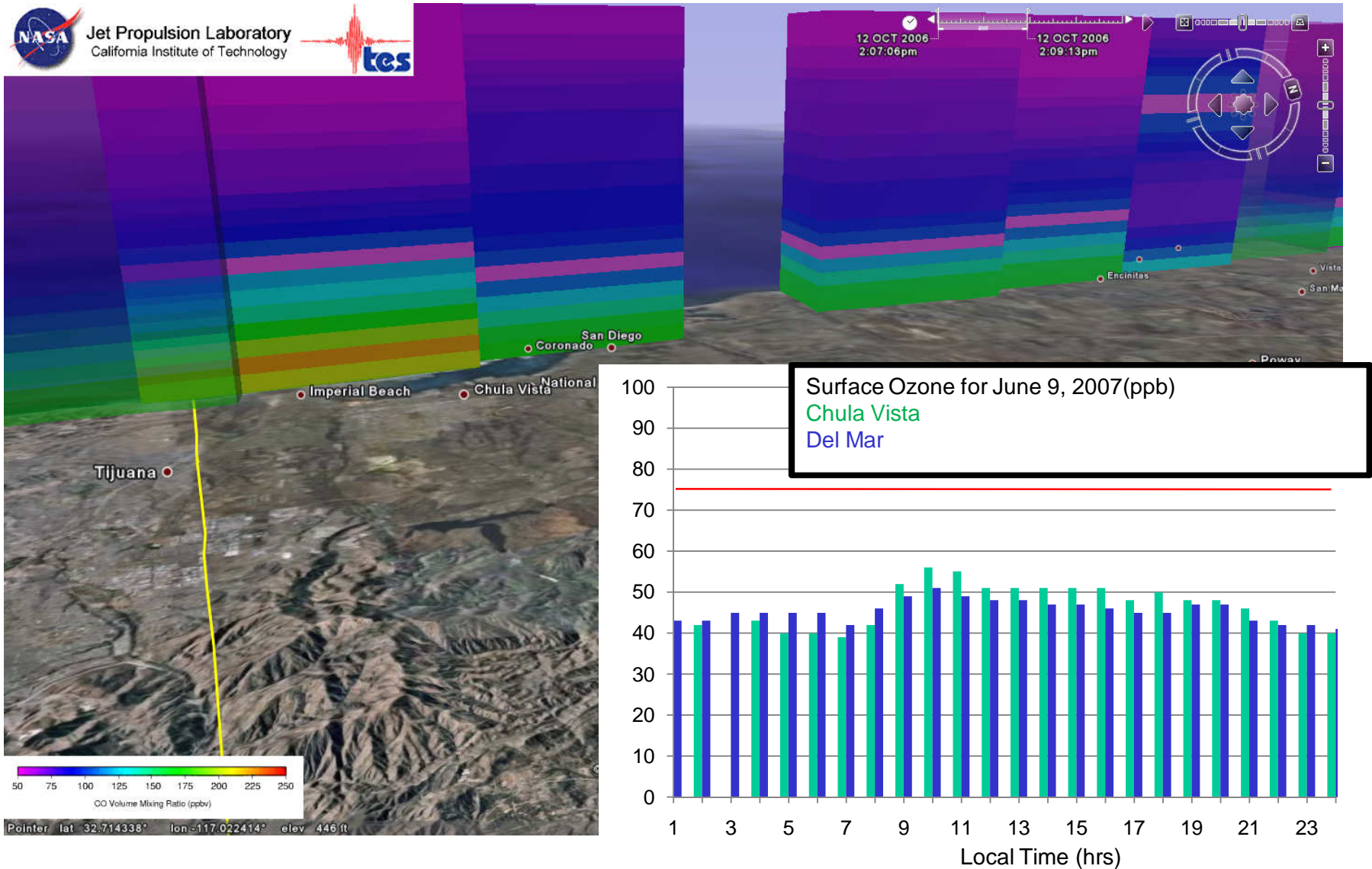




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## Tropospheric Emission Spectrometer

June 9, 2007 – TES Transect over US/Mexico Border



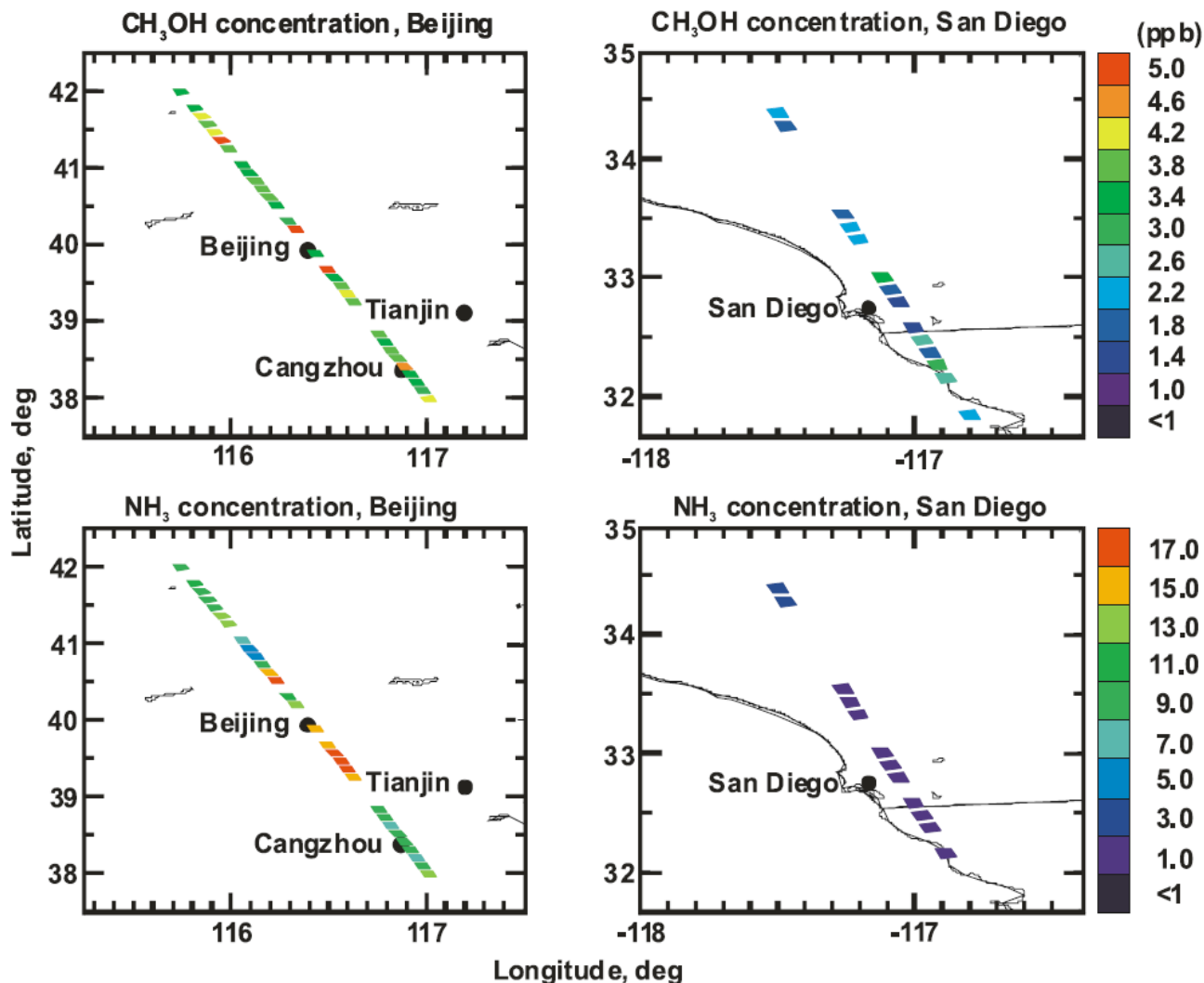


# *Tropospheric Emission Spectrometer*

## Retrievals of Ammonia and Methanol

BEER ET AL.: TROPOSPHERIC AMMONIA AND METHANOL

- $\text{NH}_3$  measurements are of great interest to air quality community.
- Difficult to measure from surface
- EPA is looking at controlling  $\text{NH}_3$  due to its role in PM formation
- Nitrogen uptake into soil, algae blooms
- Spatial, seasonal distributions are not well known
- TES developing  $\text{NH}_3$  product (Shephard, Luo)
- Special observations over San Joaquin Valley
- See poster presentation – M Shephard, Wed PM





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## ***Tropospheric Emission Spectrometer***

- *Is there information of value for air quality modeling and analysis in the current tropospheric column and profile data?*

– Yes

- For details and links to data go to:

**<http://tes.jpl.nasa.gov>**

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